How to Meet the Five Requirements for Accurate, Predicted Fire

(And What to Do If You Can't)

by Captain Christopher A. Patton

The goal of the FA is to provide *accurate* first-round fires for effect (FFE), yet many units at our combat training centers (CTCs) experience difficulties in accomplishing this goal. For accurate FFE, you must meet the five requirements for accurate, predicted fire: accurate target location and size, firing unit location, weapon and ammunition information, meteorological data and computational procedures.

Sometimes meeting these requirements in the more traditional means described in the manuals is not possible. Then units must meet them in non-typical ways or even take steps to improve their firing data until they can meet the five requirements. (In some cases, units may meet the requirements but find it necessary to isolate position constants.) But unless you've trained at home station to meet the five requirements for accurate, predicted fire in non-typical ways, life at the CTCs can be difficult in rotations designed to force units to train in ways anything but typical.

No FA reference outlines specifically what to do if we can't meet the five requirements or how to improve firing data under varied circumstances. This is largely due to the many mission, enemy, terrain, troops and time available (METT-T) variables a unit can face—not to mention the unit's training level, equipment, organization and other considerations. This article fills that void by discussing common techniques to meet the five requirements and steps to take to improve firing data if you can't.

Five Requirements

Page 1-3 of *FM 6-40 (FMFRP 6-6-40) Tactics, Techniques and Procedures (TTP) for Field Artillery Manual Cannon Gunnery* and Chapter 1, Section II of *ST 6-40-2 Field Artillery Battery Computer System (BCS) Cannon Gunnery* outline the common means of achieving the five requirements. Although the non-typical means discussed in this article may not be accurate enough, you should compute firing data with the most accurate means available to you in a given situation (METT-T) and evaluate your effects— whether by adjusting fire the first time, firing to a flank or even to the rear to maintain the element of surprise. Obviously, if you achieve the desired effects, then continue to fire.

I Accurate Target Location and Size. This requirement is the forward observer's (FO's) responsibility, but the artillery unit ensures its FOs can locate targets accurately. Optimally, all observers will be on common survey with their firing units. (For information on common survey, see Appendix E of ST 6-40-2.)

Units typically accomplish this requirement with their organic survey elements. This provides the observer the three elements of common survey (in order of importance): direction, location and altitude. The observer then can orient a ground/vehicular laser locator designator (G/VLLD) or man-transportable laser target designator and rangefinder (MULE) on the survey-determined direction and report the grid and altitude to the fire direction center (FDC). With this information, the unit should have few problems meeting this requirement.

If a unit can't meet Requirement I in this way, there are alternate methods it can use to determine direction, location and altitude with varying degrees of accuracy. (See Figure 1.) The techniques work if the unit has the appropriate equipment (planning is critical here) and knows how to use it.

It is unlikely, in most cases, however, that a unit can determine direction but not location. Trilateration is a useful technique for most situations if an observer has a laser capability. This technique provides both location and direction.

II Accurate Firing Unit Location. This requirement is the responsibility

of the firing unit. Optimally, organic survey elements will provide survey data allowing firing units to meet this requirement and be on common survey with the rest of the unit and the observers. If not, units can employ one of the methods listed in Figure 2.

Similar to meeting the first requirement, these methods need certain equipment and training and only can be exercised under certain conditions (for example, when a celestial object is visible for a simultaneous observation).

None of the alternatives listed in Figure 2 are accurate enough to be consid-

Direction	Page Reference
▪ Conduct a simultaneous observation with a firing unit/mortars.	*FM 6-50 (MCWP 3-1.6.23) Tactics, Techniques and Procedures (TTP) for the Field Artillery Cannon Battery* (97), Page 5-2
▪ Conduct a trilateration mission with the fire direction center (FDC) or a forward-entry device (FED).	*ST 6-40-2 Field Artillery Battery Computer System (BCS) Cannon Gunnery* (Version 0.022), Page 5-35
▪ Conduct any of the methods outlined in this article for determining accurate firing location (see Figure 2), assuming the availability of the backup computer system (BUCS) and/or an aiming circle.	
▪ Scale a direction from a terrain feature visible on a map.	
Location	
▪ Use the AN/PSN-11 precision lightweight global positioning system receiver (PLGR).	FM 6-50, Page 4-6 *TM 11-5825-291-13 PLGR Technical Manual*
▪ Conduct a resection (Page 5-34), triangulation (Page 5-37) or trilateration (Page 5-35) mission with the FDC or a FED.	ST 6-40-2
▪ Conduct a graphic resection.	FM 6-50, Page 5-13
▪ Conduct any of the methods outlined in this article for determining accurate firing location (see Figure 2), assuming the availability of BUCS and/or an aiming circle.	
▪ Determine location by mapspot.	
Altitude	
▪ Determine the altitude from the trilateration or resection mission used to determine location.	ST 6-40-2
▪ Use the PLGR.	TM 11-5825-291-13
▪ Determine the altitude by mapspot.	

Figure 1: Forward Observer Methods to Determine Direction, Location and Altitude without Survey Data

Direction	Page Reference
▪ Conduct a simultaneous observation (Page 5-2), Polaris 2 (Page 5-10), Polaris - Kochab (Page 5-3), or directional traverse (Page 5-11).	*FM 6-50*
▪ Conduct a BUCS hasty astro.	*ST 6-40-31 FA Backup Computer System (BUCS)* (Dec 90)*, Page 2-52*
Location	
▪ Conduct a graphic resection.	*FM 6-50, Page 5-13*
▪ Use a PLGR.	*FM 6-50, Page 4-6/TM 11-5825-291-13*
▪ Determine the location from a mapspot.	
Direction and Location	
▪ Conduct a graphic traverse.	*FM 6-50, Page 5-14*
▪ Conduct a BUCS graphic traverse.	*FM 6-50, Page 5-23*
Altitude	
▪ Use the PLGR.	
▪ Determine altitude by mapspot.	*FM 6-50, Page 4-6/TM 11-5825-291-13*

Figure 2: Firing Unit Methods to Determine Direction, Location and Altitude without Survey Data

ered common survey; however, they might be enough to allow you to meet the goal of the FA and achieve an accurate first-round FFE.

III Accurate Weapon and Ammunition Information. The tangible elements of this requirement are propellant temperature, projectile square weight and muzzle velocity variation (MVV). Units should have little trouble measuring the propellant temperature with enough temperature gauges on hand for all contingencies. Reading the square weight on a projectile and reporting it to the FDC is also a simple task.

Muzzle velocity management, on the other hand, is far more difficult. Optimally, we calibrate every round fired with the M90 or M93/94 chronograph. I discuss all four of our MV management options briefly in this article with the techniques found in FM 6-40, Chapter 4.

Calibrate with the M90 or M93/94 Chronograph. This is the most reliable method to determine MVV. Optimally, calibration should be continuous. If you calibrate with the M90, you must correct for nonstandard propellant temperature and projectile square weight with the Muzzle Velocity Correction Table-1 dated June 1996 or by entering the appropriate data into the BCS;MVD message format of the BCS.

The M93/94 determines a calibrated MVV, and you enter this directly into the BCS;MVV file as historical data.

Perform a Subsequent Lot Inference. Once you have a baseline MVV for all howitzers, you can infer second-lot MVVs if you receive a different lot of propellant. Calibrate the second lot with a single howitzer and infer to other howitzers using the DA Form 4982-R (MV Record).

Use the equation MVV=SS+PE. You can predict the MVV of a particular weapon with a particular lot of propellant by determining shooting strength (SS) by using the weapon's 2408-4 Weapons Record Data/Gun Book and the tabular firing table (TFT). Determine the appropriate propellant efficiency (PE) for the lot of propellant and add it to the SS to determine a predicted MVV. PEs are available on the Fort Sill Home Page under the "Training Command" menu in the Gunnery Department's Fire Direction Branch section with a discussion of how to use them.

Use SS alone to estimate MVV. If no PE is available for the lot of propellant you have, you may consider using SS alone. Often this will provide more accurate firing data than using standard firing table MV. If you can't use one of the other three methods for whatever reason, this is a technique to determine more accurate firing data than you currently have. But the only way to verify the accuracy of the data is to fire it and evaluate your effects.

If you can't calibrate every gun, or at least one and infer MVVs for the others, then the last two techniques may help you in meeting Requirement III. If you do not have PE information, however, your fires most likely will be inaccurate. Once you verify your fires and find them inaccurate, you should consider the five steps to improve your firing data also outlined in this article.

IV Accurate Meteorological Information. Unfortunately, if a meteorological section doesn't have a meteorological message available when you need it, there's no alternate means to determine the effects of the weather. A confident fire direction officer (FDO) might consider estimating his own meteorological data at line 00 by estimating wind speed and direction (and temperature for that matter). See *FM 6-15 TTP for Field Artillery Meteorology* for more information.

Additionally, an FDO who keeps a log of the previous day's meteorological messages may consider using a day-old message flown at the same time as he currently is firing as a possible improvement to his current firing data. Of course, this means is not ideal and anyone considering it must use common sense and evaluate the similarity of the previous day's weather to the current day's. This solution may, however, improve data determined with a six-hour-old or a standard meteorological message and can be evaluated by firing.

You also simply can fire with a standard meteorological message and evaluate the effects of your rounds based on the best data available (excluding the meteorological message, in this case). This will determine whether or not you met your goal. If so, then continue to FFE. If not, then begin the five steps to improve firing data.

V Accurate Computational Procedures. If you fail to perform any required computations correctly, you probably won't fire accurately. Then you have to identify the incorrect data by reviewing your BCS database. Proper procedures in the FDC should identify any errors before you fire—via conducting check missions and verifying all data fired by an independent means (BCS to manual computations).

Proper troubleshooting techniques after your observer identifies inaccuracies will enable you to quickly identify and correct any errors in your computation of firing data and allow you to continue the mission.

If you have done your best to meet all five of the requirements for accurate, predicted fire by the best means available, your next step is to assess your accuracy. If you achieve the goal of first-round FFE, then go forth and kill the enemy. (It's probably a good idea to begin with an adjust fire mission or a mission fired well into enemy territory to verify your accuracy and avoid fratricide. Again, this depends on your situation). If you did not fire accurately, it's time to improve your firing data.

The Five Steps to Improving Firing Data

We address the process of registering and subsequent techniques as the five steps to improve firing data and not just "registering" for more than just semantic reasons. It is a conscious decision on the part of the FDO (with the approval of the commander) to perform these steps for the benefit of the entire unit and not just for the immediate benefit of one platoon, which would be the result of just "registering." (See Figure 3.)

The five-step process allows the unit—probably a platoon for its battalion but could be multiple battalions)—to isolate position constants and transfer this information to the other platoons and, thereby, mass the fires of the battalion. Additionally, this process requires the

1. Cause the rounds to burst at a point of known location.
2. Determine did-hit and should-hit data.
3. Determine the total corrections.
4. Isolate position constants.
5. Update the total corrections.

Figure 3: Five Steps to Improving Firing Data. These are the steps to take to improve your firing data when you are unable to meet the five requirements for accurate, predicted fire by the best means available. (Steps four and five keep you from having to register again.)

unit to register just one time (optimally) and merely update total corrections over time as measurable nonstandard conditions change and are updated in the BCS database.

This process assumes you eventually will obtain the necessary information and isolate position constants by stripping the measurable nonstandard conditions (Big Met) out of the AFU;REG file. (Big Met is all the measurable, nonstandard conditions for which you can account.) Removing these conditions enables you to transfer this information to other units as long as both units are on common survey. For example, if you don't meet Requirement II, you can expect survey to get to your unit eventually. If you don't meet Requirement III, you *will* meet it after you calibrate the registering howitzer during the registration. And if you don't meet Requirement IV, you can arrange to have a message determined by the meteorological station when you register or as close to that time as is possible. (The Requirement I is the FO's responsibility and Requirement V is to ensure computations are performed correctly.)

The FDO's Decision Flow Chart in Figure 4 helps FDOs determine whether or not they should conduct the five steps to improve firing data and, if so, what registration techniques they should use. Conducting a registration requires significant ammunition and time and puts the registering unit at risk to enemy counterfire. Therefore, a registration should not be an automatic answer to

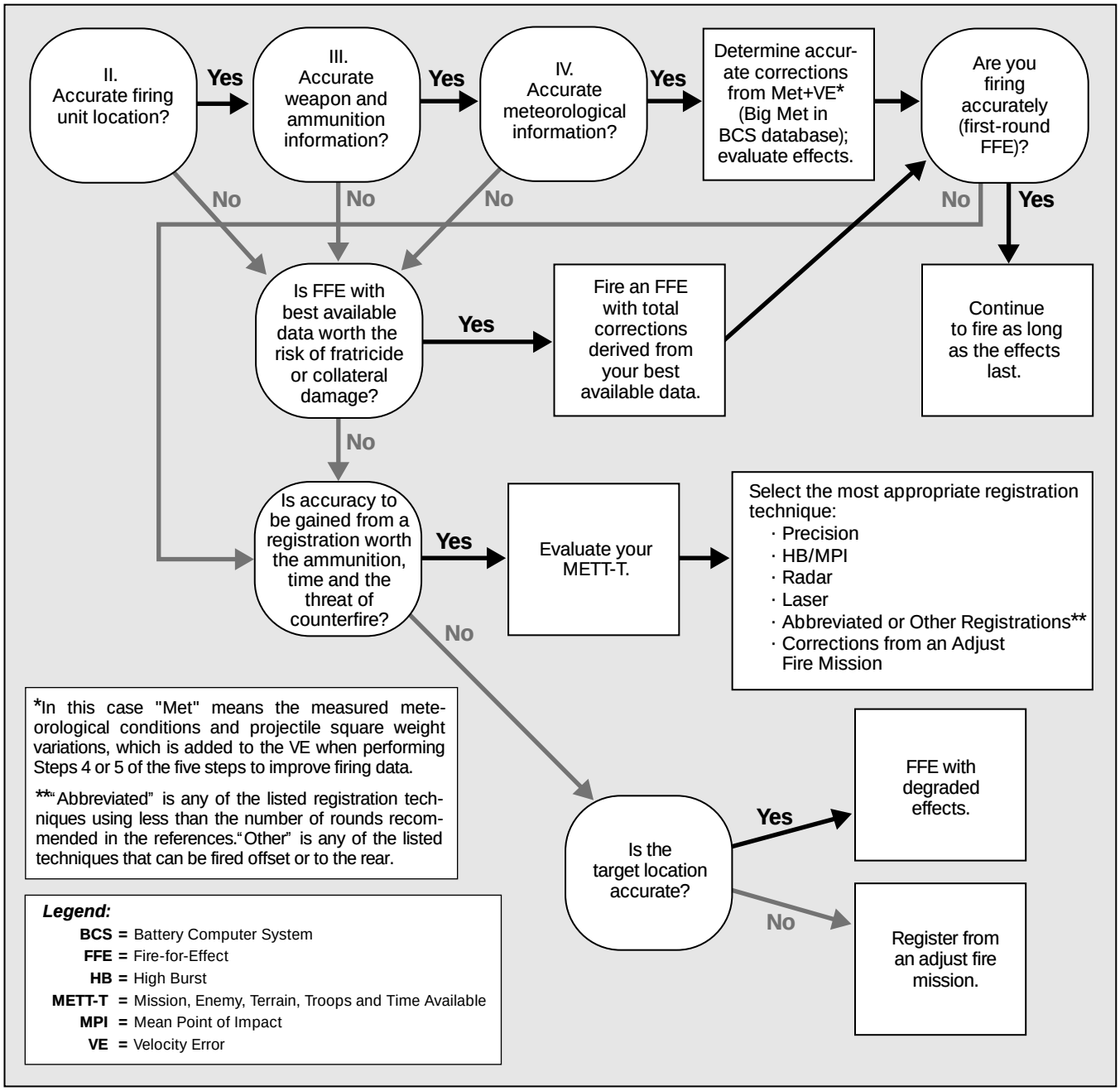

Figure 4: FDO's Decision Chart. This flow chart helps the fire direction officer (FDO) determine whether or not to register and, if so, what registration technique to use. The FDO enters the chart at the top left with Requirements II, III and IV. For Requirement I, Accurate Target Location, the FDO has to depend on the forward observer's (FO's) having done his job correctly. (Requirement V, Accurate Computational Procedures, applies to the FDO's computation, identification or verification of all data.)

not meeting the five requirements. (See Figure 5.)

Which registration technique you choose depends on a myriad of factors conveniently grouped under METT-T. Here are two scenarios with varying METT-T.

First Scenario. Your unit is meeting the five requirements for accurate, predicted fire and is firing accurately. As night falls, the meteorological station rolls over in a ditch while moving from one location to another. Your unit continues to fire accurately until the weather changes significantly after sundown.

You don't have a method to meet this requirement, so you decide to conduct the five steps. If the meteorological station will be back up soon and you can wait, you might conduct a registration with one unit and have that unit transfer position constants after conducting a concurrent meteorological technique. (You might also consider transferring position constants if all your units are fairly close together and firing generally on the same azimuth of fire, but this is not the best choice.) If the meteorological station will be down for a while, you might consider conducting a registration with all your units, but this only will improve firing data until the weather conditions change again.

In this scenario, you have only one observer in position. You have 30 minutes until you need to fire, so you have time available. Your observer has a G/VLLD, so you decide to conduct a laser registration. (If you had a radar and could use it, conducting a radar registration would be preferable.) The laser registration is faster and uses fewer rounds than a precision registration and can yield a higher assurance of validity using the typical number of rounds (six).

Registration Technique	Page Reference
Precision Registration	ST 6-40-2, Page 5-40/*FM 6-40 (FMFRP 6-6-40) TTP for Field Artillery Manual Cannon Gunnery* (96), Page 10-6
▪ HB/MPI Registration	ST 6-40-2, Page 5-46/FM 6-40, Page 10-16
▪ Radar Registration	ST 6-40-2, Page 5-51/FM 6-40, Page 10-34
▪ Laser Registration	ST 6-40-2, Page 5-57
▪ Registration from an Adjust Fire Mission	ST 6-40-2, Page 5-56
▪ Any Abbreviated Form (Less Usable Rounds) of These Registration Techniques	

Figure 5: Registration Techniques and References

Second Scenario. In this scenario, you also lose meteorological support, but you are in the middle of providing continuous support to your maneuver units. In this situation, you notice your fires become inaccurate with the changing weather and you can't afford to adjust fires due to the highly mobile enemy forces attacking friendly units.

This time you wisely decide to take corrections from your last adjust fire mission and use them as registration corrections. Even though you have to repeat this process as weather conditions change, this technique will keep you and your fellow units in the fight until the meteorological station can resume operations.

FDOs and commanders at all levels must be familiar with and train on alternate means to allow a unit to fire accurately if it can't meet the five requirements for accurate, predicted fire by typical means. If the unit can't meet the requirements, understanding the different registration options will allow it to quickly improve firing data in a manner that yields the most accurate firing data with the artillery out of the fight the least amount of time.

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DAC-Futures Formed at the FA School

In July, the Field Artillery School at Fort Sill, Oklahoma, created the office of the Deputy Assistant Commandant for Futures (DAC-Futures). This office pulls together the research, development and resourcing efforts of the Depth and Simultaneous Attack Battle Laboratory (D&SA Battle Lab), Task Force 2000 (TF 2000) and the Directorate of Combat Developments (DCD). DAC-Futures integrates all futures work in the near term and out to Army After Next and beyond at the Center for Fires, Fort Sill. The center's efforts now more closely align with the futures development and procurement efforts of Headquarters, Training and Doctrine Command (TRADOC).

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